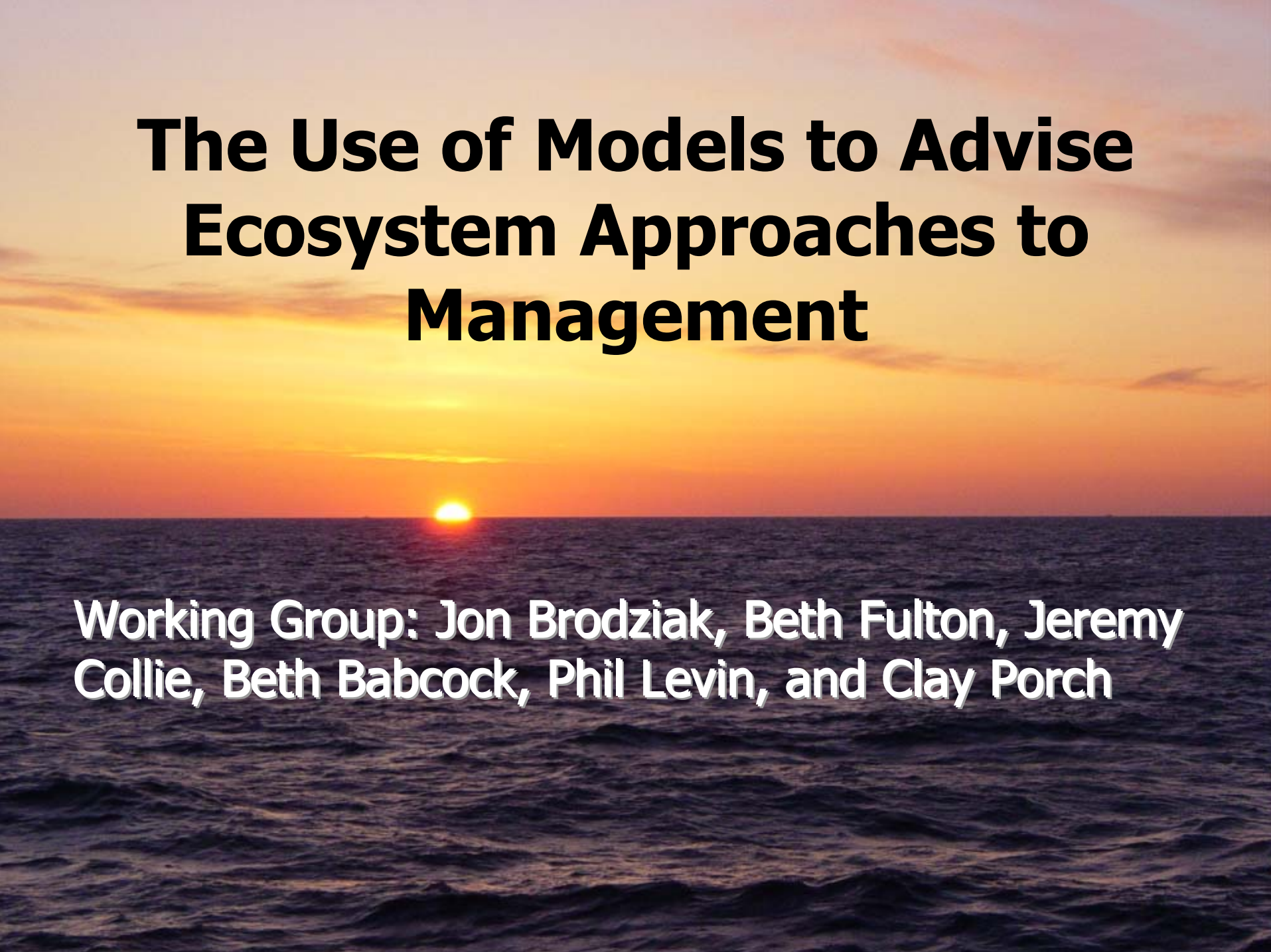
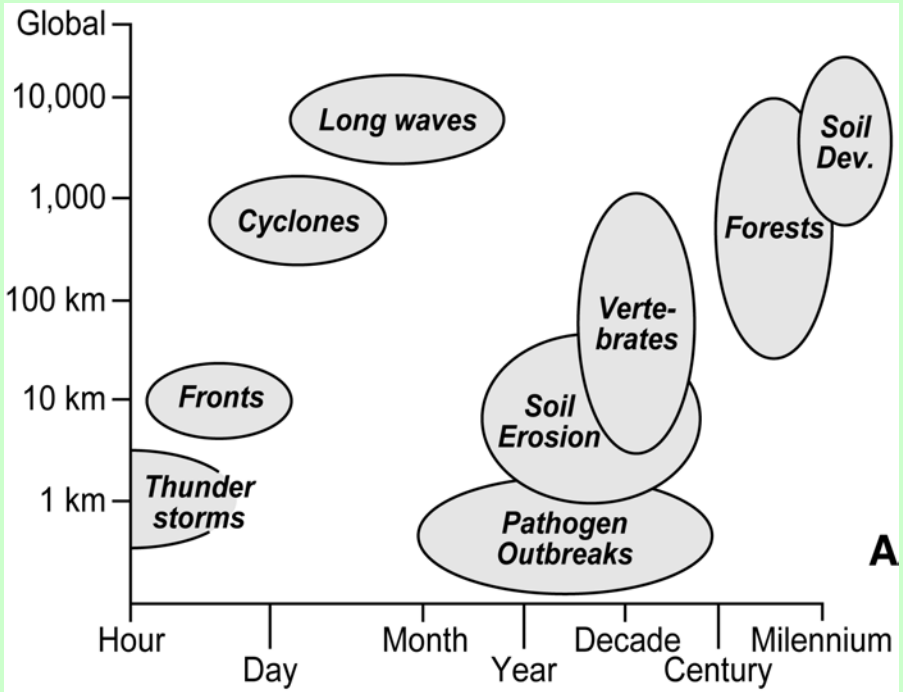


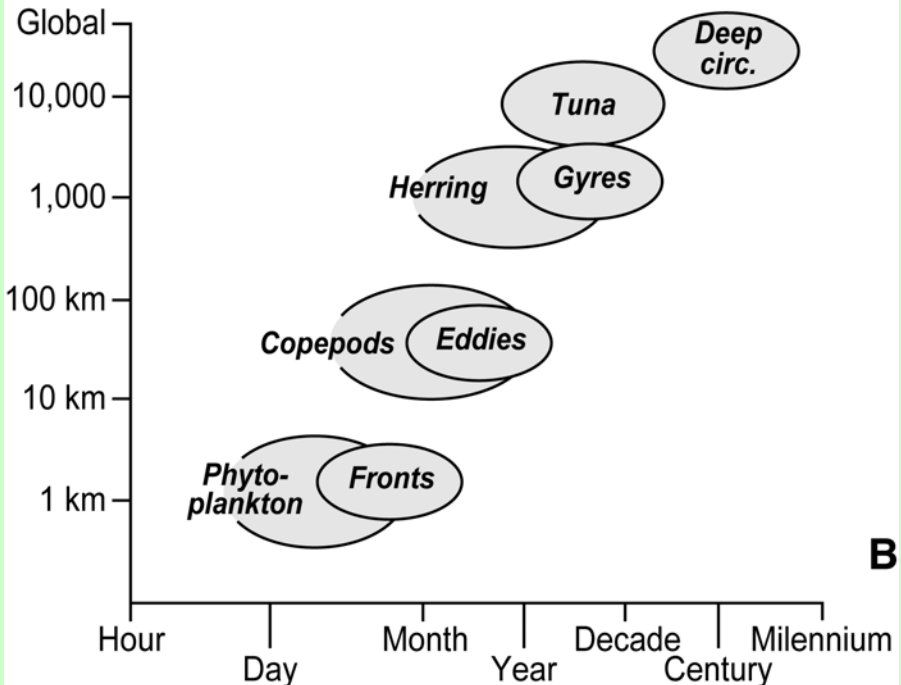
The Use of Models to Advise Ecosystem Approaches to Management

Working Group: Jon Brodziak, Beth Fulton, Jeremy Collie, Beth Babcock, Phil Levin, and Clay Porch

Ecosystem modeling: What is the current state of the art?

Multispecies and ecosystem models have been used to approximate the complex and dynamic interrelationships among biotic and abiotic processes occurring over a range of spatial and temporal time scales. Simple models can be used to show the relative consequences of alternative management strategies.





Some important categories of multispecies and ecosystem models

	Biological interactions described	Predator-prey feedback	Handles environment and/or lower trophic levels	Handles age structure	Add spatial structure
MS fishery technical interaction models					
SS models plus unidirectional drivers	X		X	X	X
MS production models	X	X			
Age/size-structured MS models	X	X		X	X
Aggregate trophodynamic ecosystem models	X	X	X		X
Age/size-structured trophodynamic ecosystem or individual-based models	X	X	X	X	X

Ecosystem modeling: Are there appropriate experiences world-wide that demonstrate how models can inform the EAF?

- **Yes! Management strategy evaluation (MSE) using ecosystem models provides a clear example of how such models can provide relevant information that is directly applicable to the ecosystem approach to fisheries (EAF)**
- **Yes, simulated annealing algorithms have been used to optimize selection of subareas for MPAs, eg. MARXAN in the northeast and Channel Islands**

Conclusions from MSE and EBFM in Oz

- Modelling lessons
  - all model types potentially useful in MSE
  - intermediate complexity is best (whether trophic/spatial/temporal/process detail)
- Ecological indicators
  - simpler is better (fewer post-processing steps the better, especially if data poor)
  - distinction between data-based and model-based indicators may be important in direct application, eg mean length versus mean trophic level

Conclusions from MSE and EBFM in Oz

- MSE highlights
  - data/monitoring gaps
  - value of qualitative info (traffic light results, optimistic-"middle of the road" -pessimistic uncertainty handling)
  - trade-offs (between fleets, sectors, ecosystem components)
  - simpler management measures often most effective
  - identifying management objectives is often the hardest part
  - including stakeholders from the beginning increases engagement
- EBFM likely to look like assessments complemented by strategic ecosystem models and indicators (and hopefully data!)

Ecosystem modeling: What new data, models, or information management systems are needed to advance the discipline and provide useful advice ?

- **Enhanced biotic (eg, consumption rates), abiotic, and socioeconomic data collection systems (feedback based on data gaps) are needed to construct more useful and relevant ecosystem models**

- **Characterizing uncertainty is vital for interpreting ecosystem model results and providing advice on the likely consequences of alternative management actions**

Ecosystem modeling: What new data, models, or information management systems are needed to advance the discipline and provide useful advice ?

- **Ecosystem models may be improved by including components to describe bioeconomics, human behavior, fisheries bycatch, essential fish habitat, and potential effects of low-frequency environmental forcing**

- **Methods from other disciplines that could be useful for EAF modeling include fuzzy logic, credibility theory, artificial intelligence, gaming theory, network analysis, decision theory, the kind of model averaging used in hurricane forecasting, and a variety of methods used in economics**

Ecosystem modeling: What changes in policy, governance, or science administration are required to more effectively implement an ecosystem approach ?

- Develop clear goals and constraints
- Coordinate management actions and research efforts, eg BACI designs for MPAs
- Foster participatory decision making
- Mandate ecosystem protection, ie, non-target species
- Provide adequate support for ecosystem monitoring, research, modeling, and management
- Sustain ecosystem services for future generations: **Intergenerational equity and the ethic of restraint**

Modeling Discussion: Spatial Scales

- **Modeling of ecosystem effects has been incremental and adaptive. Many ecosystem models have been derived from single species population dynamics with elaborations for ecosystem issues of increasing complexity**
- **Spatial and temporal processes in ecosystem models need to be integrated across broader and finer scales**
- **Spatial domains of ecosystem models often reflect tradeoffs regarding boundaries and knowledge of biotic and abiotic fluxes across them**
- **Spatial aspects of management, both ecological and bioeconomic, need explicit consideration for effective implementation of EAF**

Modeling Discussion: Using Management Strategy Evaluation for EAF

- **Management strategy evaluation analyses imbed population and ecosystem dynamics within the management system**
- **MSE provides results that can be quantitative, directional, semi-quantitative or qualitative**
- **Benefits of MSE can be expected in the modeling process (collaboration) and in the assessment of tradeoffs**
- **Decision makers have to transparently operationalize objectives**

Modeling Discussion: Using Management Strategy Evaluation for EAF

- **Selection of relevant indicators and strategies must be collaborative (with stakeholders) and iterative as well as adaptive**
- **Understanding behavioral responses of people to management is an important aspect of MSE (implementation error)**
- **Who is allowed to be a "stakeholder" in the MSE process? Who determines this?**
- **Random utility or other social science models may be useful submodel components.**

Modeling Discussion: Evaluating Alternative Ecosystem Models for EAF

- **Evaluating alternative working hypotheses is important to address scientific uncertainty about the relative importance of multiple causal mechanisms in complex ecosystems.**
- **It is desirable to use multiple models looking at differing mechanisms & scenarios.**
- **Structured systems to evaluate multiple hypotheses and explain outcomes requires different models, especially in a formal adaptive management approach.**
- **What are appropriate inference procedures for the selection of likely model structures ?**

- **Inferential methods to evaluate the relative credibility of competing hypotheses would be desirable, eg, Bayesian methods for model selection or model averaging**

Modeling Discussion: Ecosystem Modeling and the Science-Policy Interface

- **What are useful societal objectives ? Optimality is not necessarily paramount or simple to define in an ecosystem context**
- **Models can be used to evaluate the transition costs to implementing EAF**
- **At what point do management decision tradeoffs occur (before modeling or after review of quantitative outputs)? Should an "open-loop" or "closed loop" management strategy be used ?**